THE INFLUENCE OF TREATMENT FOR INTESTINAL TOXEMIA ON MENTAL AND MOTOR EFFICIENCY

BY
ALICE E. PAULSEN, PH.D.

ARCHIVES OF PSYCHOLOGY
EDITED BY R. S. WOODWORTH
No. 69

NEW YORK
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ACKNOWLEDGMENT

The writer is indebted to Dr. J. H. Kellogg of the Battle Creek Sanitarium, at Battle Creek, Michigan, for suggesting the problem as well as affording the opportunity to conduct this research, and to Dr. Max G. Schlapp of New York City for the generous leave of absence from her former duties in his clinic, to permit time for the work at Battle Creek. She is indebted also to Dr. Linda Roth and Miss Lenna Cooper of the Sanitarium Schools and to Miss Ina Atwood of the Berkeley Institute of Brooklyn, N. Y., for assistance in securing the co-operation of the students who acted as subjects. For valuable help in the selection of subjects for the toxic group she is indebted to Dr. Marjorie Harbaugh, examining physician for students, and to Dr. H. Tsuchiya, Chief of the Sanitarium laboratory staff. To the subjects themselves hearty thanks are due.

To Professors R. S. Woodworth, A. T. Poffenberger, H. L. Hollingworth, and Dr. H. E. Garrett of Columbia University, she desires to express deep appreciation for their constant interest, helpful criticism, and advice regarding the plan of the investigation and the statistical treatment of the data.

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PREFACE

Since the publication of Bouchard's[1] work on Auto-intoxication[2] in 1887, there has been great interest in the possible poisonous effect of bacterial products absorbed from the intestines. In many instances investigators have made unwarranted statements, but it has been established beyond reasonable doubt, that although certain forms of harmful bacteria may practically always be found to some extent in the intestinal tract, it is also possible for the organism under certain conditions to suffer severe injury, either because the normal barriers to the absorption of the toxins that are elaborated by these bacteria are broken down, or because these toxins are for some reason produced in excessive quantity.

Whenever intestinal stasis exists for one reason or another, harmful bacteria are produced in excessive quantities, and the body is unable to cope successfully with the rapid accumulation and virulence of the resulting poisons. The physical effect of this condition has been so clearly demonstrated that it has become a matter of universal practice for the physician to look into his patient's habits of elimination among his first inquiries upon being consulted for treatment. If a condition of constipation, chronic or acute, exists this usually receives immediate attention. By means of laxatives or other measures the intestinal tract is cleared, with the result that the poisons accumulated there are reduced in quantity. Almost everyone has experienced at one time or another the distress accompanying improper functioning of the eliminative organs and the general improvement in condition attendant upon remedy. Clinically, it has been demonstrated again and again that a marked improvement follows purgation.

The discoveries and observations of Pasteur, Poehl, Metchnikoff, Tissier, Pavlov, Cannon, Elliott, Keith, Case, and others have done much in recent years to throw light on the far reaching and pernicious influence of the harmful bacteria that infest the colon in many chronic diseases, and by their

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[1]Professor of Pathology and Therapeutics; Physician to the Hospitals of Paris; Member Academy of Medicine.

[2]"Auto-intoxication or Self-Poisoning of the Individual," translated by Oliver, 1906.

presence in great numbers thus elaborate the formation of powerful toxins in excessive quantities.

But the significance of the colon as a factor in disease is by no means a modern notion. Going back to Herodotus we learn that the ancient Egyptians kept themselves in good health by purgation employed regularly once each month. Hippocrates also emphasized the importance of purgation. Indeed the "opening purge" is one of the most recurrent recommendations found in the works of the older medical writers.

Mineral spring resorts, some of which have been famous for centuries, and the enormous number of laxative remedies on the markets are convincing evidence of the widespread recognition of the relation between conditions in the colon and human morbidity.

Mental effects of intestinal toxemia have likewise been noted by various observers. Van Noorden,[3] for instance, describes a condition of neurasthenia with polyneuritis due, as he holds, to intestinal toxemia and relieved by the removal of this condition.

Sir Lauder Brunton[4] states, "The bacillus coli seems to have a special power of producing fatigue toxins and many people in whose intestines it exists in great abundance suffer from constant weariness and a feeling of fatigue."

Dr. J. F. Briscoe[5] remarks,"Who has not seen a prodigious evacuation of the bowels at the hands of the physician terminate a case of insanity, and on the other hand, has not observed the skill of the surgeon unfold the mechanical obstruction that has led to the deadly consequences of intestinal putrefaction."

"It is obvious that constipation is only a link in the series of causes and consequences arising from the disturbed abdominal viscera and on the mental side encourages and accentuates such symptoms as apathy, irritability, perverted moral feelings, melancholia, mania, nay suicide: while on the bodily side it produces marked emaciation, rheumatism, cachexia, and a long string of diseases."

Sir Lennox Wainwright,[6] Hon. Physician to St. Michael's

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[3]Report by Van Noorden, published in the Journal of the Amer. Medical Assoc., Jan. 11, 1912.

[4,6]Reported in Proceedings of the Royal Society of Medicine, Vol. VI, No. 5 and No. 7. "A Discussion on Alimentary Toxemia; its Sources, Consequences and Treatment" carried on at meetings held March 10 and April 14, 1913.

[5]See report of meeting of Royal Society of Medicine, Mar. 10, 1913.

Aid Society and Physician to the Society for the Prevention of Cruelty to Children, of London, states, "I am quite sure of this, that the mental effect on many patients of prolonged intestinal toxemia is such as to make them almost demented and I believe that if many of our asylums were invaded by a good sound clinical physician, who would approach the subject without any preconceived idea, in many cases supposed to be hopeless, the melancholia and hypochondria would yield to common-sense treatment and reduce the number of insane[7] people."

The importance of combating and eliminating or decreasing the proportion of harmful bacteria in the colon has long been recognized in the treatment of patients at the Battle Creek Sanitarium. Great emphasis is placed on "changing the intestinal flora," and the various methods[8] of accomplishing this have been tried out there over a course of many years and on thousands of cases.

In the Fall of 1922 this institution offered the writer the opportunity to attempt to determine, by means of mental tests, the effect of intestinal toxemia, due to a superabundance of pernicious bacteria, on mental and motor efficiency. It was originally planned to measure the capacity of patients before treatment at the sanitarium, to repeat the measurements after a certain period of treatment, and then to calculate the effect of such treatment on the basis of any differences that might appear in the two performances of the mental tests.

Unfortunately, not enough cases uncomplicated by other physical conditions that might influence the test results could be secured from among the patients, in the comparatively short time at the examiner's disposal. Nor could extraneous conditions such as the length of stay of the patients be sufficiently controlled. Therefore, the use of sanitarium patients as subjects of the experiment was abandoned as impracticable.

However, the schools[9] connected with the Sanitarium provided a substitute fairly satisfactory for the purpose. The

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[7]Experiments with the insane on Ward's Island are now being carried on by Dr. Kopoloff who has succeeded in changing the intestinal flora, following the methods used at Battle Creek. The work has not as yet yielded substantial results as far as the mental condition of the limited number of subjects treated is concerned. Dr. Kopoloff is not ready to pass definite judgment upon the matter at this time.

[8]See Kellogg, "Auto-intoxication or Intestinal Toxemia."

[9]Domestic Science and Physical Education.

experiment was done shortly after the beginning of the academic year. Students entering these schools and patients entering the sanitarium are subjected to the same routine physical examination, very thorough in character. A student found in need of it is given opportunity to avail herself of treatment at the sanitarium.

Though in a milder form than that found among patients who have sought the institution especially for treatment, intestinal toxemia is a frequent occurrence among students, owing to their sedentary and irregular habits.

The physical examinations at entrance disclosed a sufficient number of otherwise fairly healthy but distinctly toxic individuals in this group of students to make the experiment possible and their co-operation was readily secured when the situation was explained to them.

The results obtained apply to a milder form of the condition than that found among the severer sanitarium cases, and are therefore subject to this limitation. However, there seems no doubt that the results secured from a study of the milder form apply to the severer form, though perhaps in greater measure. That is to say, if the mental efficiency is decreased in the milder cases of intestinal toxemia it would seem safe to suppose that it is decreased as much if not more in the severer condition.

A detailed description of the experiment and the results obtained will be given presently.

I. The Nature of the Condition under Consideration

The terms Intestinal Toxemia and Intestinal Auto-intoxication are frequently confused or used interchangeably. Auto-intoxication in the strict meaning of the term means an intoxication resulting from the action of certain materials elaborated by the tissues of the body during metabolic activity. It has no reference to the toxins resulting from bacterial activity, whatever the site of production.

But toxins may be elaborated by the bacteria that habitually inhabit the intestinal tract and these may under certain conditions be absorbed so that they injure the organism. Such intoxication is Intestinal Toxemia, a toxemia resulting from the absorption or accidental inoculation of the body with an

exogenous toxin, rather than auto-intoxication, which is distinguished as endogenous. In this experiment we are dealing with Intestinal Toxemia as thus differentiated from Auto-intoxication.

Normally there are found in the intestinal canal or colon both useful, beneficent bacteria or flora, and useless, pernicious bacteria or flora. The useful prevent the growth of the useless and render beneficent services to the body. They are helped in controlling the growth of the harmful bacteria by the bile and other provisions of nature. If, in addition, the diet is such, and elimination is so regulated, that putrefaction is reduced to a minimum, the pernicious bacteria cannot dominate. But if they do get the upper hand, they assist in the production of toxins which may be absorbed and cause intestinal toxemia in a degree dependent upon the amount of absorption taking place, the number and virulence of the bacteria present.

This is the theory followed at the sanitarium, where the proportion of beneficent versus pernicious bacteria present in the intestinal tract as shown by an analysis of the feces figures to a great extent in the diagnosis of intestinal toxemia. The cases used for this study were chosen largely by this method and the improvement in intestinal condition was measured by the increase in the number of useful flora and the corresponding decrease in the number of pernicious flora following a systematic course of treatment directed at the source of the condition.

Whether any particular element of the treatment or the end result of the total regime, namely the change in flora, or whether the treatment as a whole is responsible for the outcome of the experiment is not entirely within the province of the psychologist to determine. Nor is it possible for one untrained along medical lines to judge the validity or relative worth of the various controversies concerning the basis of diagnoses or methods of treatment.

The writer has accepted the diagnosis of intestinal toxemia in the case of the subjects of this experiment on the authority of sanitarium physicians and based on the sanitarium method. The conclusions also are drawn with reference to the situation as a whole rather than to any particular element of it.

II. Method of Procedure

Two groups of subjects, thirty in each group, were used. These will be designated as Group I and Group II. Group I was made up of individuals known to be toxic, and Group II of subjects not examined for toxicity but selected merely as a suitable control for Group I.

Group I consisted of young women entering the Normal School for Physical Education and the Domestic Science Training School connected with the Battle Creek Sanitarium. All were high school graduates. One had a college diploma.

Every new student at the Sanitarium Schools is given a thorough physical examination and as part of this examination she is required to send a specimen of her feces to the laboratory for analysis. With the assistance of the examining physician for the schools and the chief of the laboratory staff, the examiner was able to choose a group of individuals from among the entering students whose condition was toxic. The analyses of the feces indicated the presence of harmful bacteria in such excessive numbers that these individuals, judged by sanitarium standards, must be suffering from intestinal toxemia of one degree or another. Though they were otherwise fairly healthy, further examination brought forth the fact that the majority confessed infrequent bowel movements, foul breath, pasty complexions, frequent headaches and other symptoms which very often accompany intestinal toxemia.

Nearing the close of the experiment the Terman Group Test A was given to group I, to assist in establishing a criterion for the choice of a control group. This test was not given before treatment, nor at the close of the treatment, so that the effect of the toxemia on this performance cannot be calculated. It was intended merely as a rough estimate of general intelligence.

Group II was chosen on the basis of the Terman Group Test A, their chronological age, training and environment. In an effort to secure a control group the group test was given to the Junior, Senior, and Post-graduate Year students at the Berkeley Institute for Girls, to a group of young women stenographers, and to some Hunter College Freshmen. The group as finally chosen was made up of 17 students in the senior year, and 2 of the previous year's graduates of the Berkeley Institute, 4 Hunter College Freshmen and 7 stenographers.

The distribution in chronological age, intelligence quotient, amount of academic work, other training and environment was as nearly like that of Group I as could be secured. It was a fairly comparable group as far as could be determined.

No attempt to measure the presence or absence of intestinal toxemia was made in the control group. The subjects were all apparently healthy individuals.

Candidates for Group I were sent to the examiner, who explained the situation to them, and offered them assistance in bettering their condition in return for co-operation in the experiment, which was portrayed merely as the performance of some mental tests to see how well they could be done by these students. They did not know the full purpose of the experiment nor that they would be required to repeat the same performances after the treatment.

Individual appointments were then made with those who agreed to act as subjects. A promise to adhere to all the requirements of the experiment was exacted. Each subject was given an appointment covering a period of two hours and instructed to send another fecal specimen to the laboratory on the morning of her appointment, in order that the examiner might check up on her condition and make sure that toxicity was present at the time.

The tests were all given within the two hours included in the appointment, which was long enough to give plenty of time for rest between tests and to complete the series without undue haste or fatigue. A record of the day, hour, and conditions attending this performance was kept, in order to enable the examiner to control the conditions for the retest at a later date.

Before leaving the examiner the subject was instructed as to her future course with reference to her condition, and the requirements of the experiment. She was told how to go about "changing the intestinal flora" and given the necessary directions concerning the use of the facilities provided by the sanitarium for her benefit.

In cases where there is no unusual complication such as mechanical obstruction or diseased condition of the colon itself, the treatment consists mainly of active elimination of the accumulated poisons, the introduction of the various media favorable to the growth of friendly bacteria, and the prevention of the growth of the unfriendly bacilli.

To accomplish the first, in ordinary cases such as Group I represented, hydrotherapeutic treatment, such as electric light cabinet, steam baths, etc., and stimulation of intestinal activity by means of exercise, the consumption of laxative and bulky foods, the addition of roughage in the form of bran or agar-agar in the dietary and in some cases the use of lubricants, like the parrafin oil preparations, are resorted to with effective results. All these were provided for our subjects.

The second is accomplished through the introduction into the intestine of various preparations, such as lactose dextrine, acidophilus milk, and other media which are known to encourage the growth of the friendly bacteria. Preparations of this sort were supplied to the subjects at the beginning of the experiment. However, few continued their use long enough to consider them as having had an active part in changing the condition of this group. Moreover, the examiner had no way of checking up on their use. Several threatened to leave the group if they were required to continue the use of these preparations, which they considered disagreeable and inconvenient to take. Therefore, since the situation did not entirely demand such strenuous treatment, and since it was necessary to keep up the enthusiasm of the group, those who rebelled were permitted to follow their own inclinations regarding this part of the treatment. Some few continued taking the preparations faithfully.

By adherence to a meatless, low protein, non-toxic dietary, composed largely of fruits and green vegetables, less prone to putrefaction, the third result is accomplished. The production of the unfriendly bacteria is reduced in this way to a minimum. Such a diet, supervised by a sanitarium dietitian, was prescribed for the subjects of this experiment.

Since many of the students were enrolled in the Normal School for Physical Education, they became subjected to strenuous outdoor exercise as a matter of course. Those not in this school were instructed to take regular daily exercise of some sort, out of doors.

Thirty students, in all, followed out the routine for approximately one month and only those who did so were called for retests. For one reason or another three or four subjects had dropped out of the original group.

Approximately one month after the first series of tests, new appointments were made with those who had been faithful

to the experiment. Care was taken to make the appointment for the same hour of the day, on the same day of the week and to keep conditions as far as possible the same as those attending the original performance. At this time a retest was made and as before all of the tests were done in the course of one two-hour appointment. The subjects were instructed to send a fecal specimen to the laboratory for analysis on the morning of the day upon which the mental test was repeated, in order to determine the condition of the intestinal flora at this time. Each test was repeated in exactly the same form as in the original series except where it was possible to substitute equivalent forms.[10]

Group II, the control group, entered the experiment as a matter of interest and desire to be of assistance to the examiner. Like the first group they were not aware that they would perform the tests again later.

The thirty subjects chosen as previously described were given the series of tests used on Group I following the same procedure as that used with Group I. Approximately one month later they, too, were re-tested just as Group I had been. No treatment or change of routine was instituted in the case of Group II.

III. The Subjects

The selection of the subjects has been described in the preceding section.

Table I shows the distribution in chronological age for both groups.

TABLE I

Chronological Age of Subjects

Age	*Frequency Group I*	*Frequency Group II*
16	0	4
17	2	4
18	6	13
19	7	3
20	5	4
21	3	0
22	3	1
23	0	0
24	2	1
25	1	0
26	0	0
27	1	0
Total	30	30
Av.	20.1	18.3
S. D.	2.38	1.7
P. E.	.29	.21

[10]See Chapter IV. Description of Tests.

The average age of Group II is somewhat lower than that of Group I, but the difference is not sufficient to be of any great significance as far as the results of the tests are concerned.

Table II shows the distribution in intelligence for both groups.

TABLE II

DISTRIBUTION IN INTELLIGENCE

Intelligence Quotient	*Frequency Group I*	*Frequency Group II*
75- 79	0	1
80- 84	1	0
85- 89	0	1
90- 94	3	4
95- 99	5	3
100-104	6	3
105-109	8	5
110-114	3	7
115-119	4	5
120-124	0	0
125-129	0	1
Total	30	30
Av. I. Q.	103.9	105.2
S. D.	8.49	15.9
P. E. Av.	1.02	1.95

Group II is slightly higher than Group I. As stated in Section II, the intelligence test was given to Group I in the course of their treatment. How they would stand in relation to Group II if this test had been done at the end of the experiment cannot be stated. The slight difference between the two groups does not appear significant, however. The actual difference between the groups is shown in Table III.

TABLE III

DIFFERENCE BETWEEN GROUPS I AND II

	Chronological age	*Intelligence Quotient*
Actual Difference	1.8 yrs.	1.3
P. E. Difference	1.7	2.2
Difference expressed in P. E. units	1.06	.60

The difference indicated is negligible.

Tables IV and V show in brief the main results of the analysis of the feces of the individuals in Group I.

Tables VI and VII show their condition after treatment and Table VIII shows the improvement due to treatment in so far as this can be measured.

The basis for the diagnosis and choice of subjects is largely bacteriological. The writer is not in a position to discuss this phase of the question, the responsibility for the choice of subjects having rested to a great extent with the examining physician for entering students and with the laboratory staff.

Some explanation of Tables IV, V, VI, VII, and VIII is necessary, however, in order that the reader unacquainted with this particular laboratory method may understand the situation.

Only the essential and measurable details are included. As previously stated, the colon ordinarily harbors bacteria of two sorts, one of a friendly, the other of an unfriendly nature. The friendly germs exert a beneficent effect, the unfriendly ones a deleterious effect upon the organism.

The proportion of friendly versus unfriendly bacteria present in the intestine can be determined by an analysis of the feces. In laboratory technique the proportion of friendly versus unfriendly bacteria in the feces is expressed as the per cent friendly versus the per cent unfriendly, on the basis of the specimen being made up of these two main types of bacteria, the total constituting 100 per cent. The specimen is also rated as very bad, bad, mixed, fair or normal, depending upon the proportion of beneficent versus harmful bacteria present and the nature of the particular bacteria which make up the good or bad groups. Thus, though two specimens may show an 85% bad flora versus 15% good, one may be rated "very bad," the other only "bad" if the bad flora in the former group proves by more detailed examination to be made up of bacteria known to be of worse types than those which make up the latter.

For instance, both colon bacilli and spore-bearing bacilli are classed as unfriendly or bad bacteria, but the spore-bearing variety is more detrimental and difficult to combat than are the colon bacilli. Though the proportion of good versus bad bacilli may be the same in the two specimens, the fact that the bad group contains more spore-bearing bacilli in the one case then in the other, makes the specimen containing more of them a worse specimen than the one in which the bad

TABLE IV

Analysis of Fecal Specimens	Before Treatment of Subjects																														
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
*Odor of Specimen	P	P	N	S	S	P	P	P	S	P	S	N	N	P	P	N	P	N	P	P	P	P	N	P	S	P	P	N	S	P
Colon-like Bacilli	c	c	c	c	c	c	c	c	c	c	c	c	d	c	c	c	c	c	c	c	c	c	c	c	c	d	d	c	c	c
Spore-bearing Bacilli	a	a	o	a	a	a	a	o	o	o	a	o	o	a	a	o	a	a	a	a	a	a	o	o	a	o	o	a	o	a
Streptococci	o	o	a	o	o	o	o	a	a	a	o	o	o	o	o	a	o	o	o	o	o	o	a	a	o	o	o	o	a	o
Acidophilus-like Bacilli	o	o	o	o	o	o	o	a	a	o	o	o	o	o	a	o	o	a	o	o	a	o	o	o	o	o	o	o	o	o
Grammes Positive Bacteria	15	15	10	15	15	15	25	25	20	10	15	5	5	15	25	15	25	15	15	15	25	15	15	15	15	5	5	15	15	15
Grammes Negative Bacteria	85	85	90	85	85	85	75	75	80	90	85	95	95	85	75	85	75	85	85	85	75	85	85	85	85	95	95	85	85	85
†Character of Specimen	VB	VB	B	VB	VB	VB	VB	B	B	B	VB	B	B	VB	B	B	VB	B	VB	VB	B	B	B	B	VB	B	B	VB	B	VB
Rating on Scale 100 = Normal	20	20	40	20	20	20	20	40	40	40	20	40	40	20	40	40	20	40	20	20	40	40	40	40	20	40	40	20	40	20

* P = Putrid. S = Sour. N = Normal.
† VB = Very Bad. B = Bad. M = Mixed. F = Fair. N = Normal.

group is composed of a less virulent type of pernicious bacteria.

Likewise, fewer harmful bacteria and more beneficent ones make the specimen a better one and its rating higher in proportion to the number of beneficient versus pernicious bacteria present and the type of beneficent bacteria making up the "good" group, some being better and more helpful than others.

Thus two specimens may show a proportion of 60% beneficient and 40% harmful bacteria and yet differ in their final rating because of a difference in the particular bacteria which constitute these groups. The presence of such bacteria as the spore-bearing bacilli in the harmful group makes the specimen, though proportionately good, lower in quality than one containing less virulent forms in the bad group. Or, the presence in greater number of such bacteria as the acidophilus-like bacilli in the good group makes the specimen thus favored of better quality than one having the same proportion of good versus bad bacilli but with less beneficent bacilli constituting the good group.

In the tables the proportion of good versus bad bacilli, the most important bacilli making up the two groups, and the final rating on the basis of these, are indicated.

The presence of good bacilli, following the terminology of the laboratory report, is shown under the caption "grammes positive," that of the bad bacilli under "grammes negative."

TABLE V

SUMMARY OF CONDITIONS BEFORE TREATMENT

								Av.
Rating of specimen	20	20	40	40	40	40	40	30
Frequency	13	2	4	2	5	1	3	
Grammes Negative	85	75	95	90	85	80	75	84.8
Grammes Positive	15	25	5	10	15	20	25	15.2

TABLE VI

Analysis of Fecal Specimens	After Treatment of Subjects																														
Subject	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
*Odor of Specimen	N	N	N	S	S	N	N	N	N	P	N	N	P	P	N	N	P	N	P	S	N	N	S	P	N	P	N	P	N	N
Colon-like Bacilli	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	b	a	a	a	a	a	a	a	a	a	a	b	a	a
Spore-bearing Bacilli	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Streptococci	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o	o
Acidophilus-like Bacilli	c	b	b	c	b	c	c	b	c	a	b	c	a	a	b	b	a	b	a	a	b	b	b	a	b	b	b	a	c	b
% Grammes Positive Bacteria	70	60	60	75	60	70	70	60	70	40	60	70	45	40	60	60	35	60	40	45	60	60	55	40	60	60	60	35	70	60
% Grammes Negative Bacteria	30	40	40	25	40	30	30	40	30	60	40	30	55	60	40	40	65	40	60	55	40	40	45	60	40	40	40	65	30	40
† Character of Specimen	N	F	F	N	F	N	N	F	N	M	F	N	M	M	F	F	M	F	M	M	F	F	F	M	F	F	F	M	N	F
Rating on Scale 100 = Normal	100	80	80	100	80	100	100	80	100	60	80	100	60	60	80	80	60	80	60	60	80	80	80	60	80	80	80	60	100	80

* P = Putrid. S = Sour. N = Normal.
† VB = Very Bad. B = Bad. M = Mixed. F = Fair. N = Normal.

TABLE VII

SUMMARY OF CONDITIONS AFTER TREATMENT

								Av.
Rating of Specimen	60	60	60	80	80	100	100	73
Frequency	1	4	3	1	14	6	1	
Grammes Negative	65	60	55	45	40	30	25	42
Grammes Positive	35	40	45	55	60	70	75	58

TABLE VIII

IMPROVEMENT IN CONDITION

	Grammes Neg.	*Grammes Pos.*	*Grade*
Average before treatment	84.8	15.2	30
Average after treatment	42	58	73
Average gain	42.8	42.8	43

In the sanitarium laboratory report the proportion of colon bacilli, streptococci, spore-bearing and acidophilus-like bacilli is indicated by the sign X, the more X's the better in the case of the good, and the worse in the case of the bad bacteria. This seems a troublesome symbol for charting purposes and in this report the letters a, b, c, and d are used, a designating one X on the laboratory report, b two, c three, and d four.

A putrid or sour specimen is worse than one which is normal in odor. This is also indicated on the charts.

To make it possible to calculate the improvement and express it in numerical terms, the writer arbitarily accorded a rating of 20 to a specimen which the laboratory report designated as "very bad," 40 to one rated "bad," 60 to "mixed," 80 to "fair," and 100 to the laboratory rating "normal."

The gain due to treatment is shown in Table VIII, the results being calculated from the gain in per cent of grammes positive, decrease in grammes negative and increase in final rating.

The average gain in condition is thus shown to be an increase of 42.8% in grammes positive and a corresponding decrease in grammes negative bacteria, with a gain of 43 points in rating of the specimen. Roughly estimated there is a rise in the average condition of the group from a state bordering on "very bad" to one bordering on "fair." A "fair" condition of the intestinal flora is almost negligible as far as indicating toxicity is concerned. Therefore the considerable degree of toxicity present at the time that the tests were first performed and treatment begun, was fairly well cleared up by treatment at the time that the tests were repeated.

IV. The Tests

Seventeen standard mental tests were used. These tests vary according to the processes they are designed to measure, and the method of measurement. In some few instances more than one test of the same process was used. This was done with a view to thoroughness and also because it was desired to ascertain in cases where more than one test was possible which form would best bring out the situation, if further research were to be undertaken. In treating the data the scores obtained from the entire series of seventeen tests are included.

Test I. The Uncontrolled Association Test[11]

This test is designed to measure the speed of association when no control of ideas is imposed. The subject is thus intructed.

"Now, I want to see how many different words you can name in three minutes. When I say 'Ready,' you must begin to name words and continue naming words as rapidly as you can. I shall keep track of them. Do you understand? Be sure to do your very best, and remember that just any words will do, like 'clouds,' 'dog,' 'chair,' 'happy.' Ready; go ahead!" The instructions may be repeated if the subject does not understand what is wanted, but this is not ordinarily necessary. The examiner keeps track of the words, writing them down if possible or making a mark on the record sheet as the subject gives each word, keeping on the watch for repetitions and other non-admissible material, recording them carefully when they occur. The time is recorded by stop watch and the record ceases at the end of three minutes after the signal "Go" is given.

Should the subject pause for 15 seconds, the examiner interjects "Go ahead as fast as you can, any word will do," or if the subject resorts to sentence form, numbers or repetition, he is reminded, "You must name separate words," or "Counting not allowed," or "Try not to repeat words." Otherwise, the examiner is entirely silent, and careful not to distract the subject in any way during the performance.

The score is the number of words, exclusive of repetitions or non-admissible material, such as numbers or words in

[11]Form described in Terman, "The Measurement of Intelligence."

sentences, given in the three minutes. A higher score indicates a better performance.

Test II. The Color Naming Test—Woodworth and Wells Form[12]

This experiment is a test of controlled association. It is designed to measure the speed with which the proper name or idea can be brought to consciousness upon sight of a familiar object, in this case a color. It is a somewhat more complex process than is the free association test. It corresponds to situations met in our daily life where we are called upon to recall the names of objects of our experience when they are directly perceived by us through some avenue of sensation.

The test blank contains 100 patches of color (besides 5 sample patches) each 1 cm. square and separated by spaces of 1 cm. from its neighbors arranged in ten rows, on a white background. The colors are red, yellow, green, blue, black, and are to be named in order, as in reading. One side is chosen as the top. The arrangement is such, however, that the blank can be equally well used in any one of the four positions. The sequence of the colored patches are so arranged as to require practically the same time for reading each of the positions. In giving the test the second time in this experiment the blank was re-read in reverse order from that used in the original reading, the blank being turned through an angle of 180° for the second test.

Preparatory to the performance, the experimenter places the blank before the subject with only the sample line of five colors showing. The subject is directed to give the names of the sample colors reading from left to right, as rapidly as possible. He is then instructed to proceed, upon the signal "Go," to read through the entire sheet in just this way. When he understands the situation the examiner uncovers the other colors, gives the signal "Go" and using a stop watch records the time required for the subject to complete the sheet. If the subject makes an error he is corrected by the examiner saying "No," and he must give the correct response before he is permitted to proceed.

The score is the time in seconds required to complete the performance. A lower score indicates a better performance.

[12]Psychological Monographs, Vol. XIII, No. 5, pg. 49, "Association Tests."

Test III. Opposites Test. Woodworth and Wells Test I. Equal Difficulty Series.[13]

This is a controlled association test designed to test facility in a more complex thought process than that involved in the color-naming test. It corresponds to situations in which one is called upon to choose from many ideas which the stimulus calls up, the one appropriate idea, to recognize it as such and express it while the false or inadequate ideas are repressed. Through this process we give, for example, in daily life, the exact answer to a question when called upon, the exact meaning of a word or the precise address of a friend, and eliminate all others from our response.

On a blank are printed in well leaded 12-point type 20 adjectives. This is placed before the subject with the stimulus words covered. He is told that the examiner will uncover the sheet and give the signal "Go," whereupon the subject is to proceed down the list of words which he will find printed in a vertical column, and without naming the stimulus word, give the opposite of each word. These instructions are reinforced by samples not in the list. When the subject understands, the blank is uncovered, the signal "Go" immediately given and the time recorded by stop watch, for the completion of the list, without error. If the subject makes an incorrect response he is stopped and must give the correct response before he is permitted to proceed. The score is the time required to complete the list without error. A lower score indicates a better performance.

Test IV. The Calculation or Constant Increment Test[14]

Similar to the opposites test, this controlled association test deals also with a task requiring a fitting and immediate response. An unexpected situation is presented and the subject must manipulate his mental processes so as to call the right idea directly to consciousness and must set up the movements of articulation to express the results of his thinking verbally. The constant increment test deals with the manipulation of numbers instead of words.

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[13]Psychological Monographs, Vol. XIII, No. 5, pg. 60, "Association Tests."

[14]"Psychological Monographs," Vol. XIII, No. 5, pg. 46. Association Tests. Woodworth & Wells.

The test blank contains 100 two place numbers, 25 in each of 4 columns. The unit places in these numbers are ten each of the figures 1, 2, 3, 4, 5, 6, 7, 8, 9, 0. In the tens places are ten 2's, ten 7's, and twenty each of the intervening numbers 3, 4, 5, and 6. These features are symmetrically distributed with reference to the halves. Each column on the sheet is so arranged as to be of equal difficulty and to take the same length of time for completion. In this experiment the first column was used for the first performance and the second column for the second performance.

The task required is to add a given number to each of the numbers in the list, calling off the results as rapidly as possible and going systematically down the list, adding the given number to each number in the list. In this instance, the number 17 was added to each of the 25 numbers in the column chosen for the test.

Placing the blank, covered, on the table before the subject the examiner instructs him as follows:

"When I uncover this blank you will see a column of 25 figures. I want you to add 17 to each of these figures mentally, and give me the answers, taking one figure after another as rapidly as possible, without pronouncing the numbers on the blank. Simply announce the answers and proceed down the list without stopping, unless I interrupt you."

These instructions may be made clearer by practice on another list containing numbers not in the test list. For instance if the list reads 64, 49, 62, 57, etc., the subject learns that he is to reply with 81, 66, 79, 74, adding the 17 mentally and proceeding down the stimulus list as rapidly as possible, merely announcing the results of his calculation.

When the directions are understood, the sheet is uncovered, the signal "Go" immediately given and the time recorded, by stop watch, for the completion of the list without error. If an error is made, the subject is stopped, the examiner holding a key to facilitate immediate detection of errors, and the correct response must be found before the subject is allowed to proceed.

The score is the time required to complete the list without error, and a lower score indicates a better performance.

Test V. The Kraepelin Addition Test[15]*—Adaptation by Woodworth and Wells*

This test, also a controlled association test, deals with the manipulation of numbers and calls upon the subject to choose the one appropriate idea from the many which the stimulus arouses. Though similar in function to Constant Increment, there are essential differences in the two tests which will appear from the description which follows. It is with the Kraepelin Addition Test that the most work has been done, perhaps.

The blank used for the test contains 24 columns of 26 digits (25 additions) in all 600 additions. It is divided into 6 sections of 4 columns each. Each section is equivalent in difficulty. One section (100 additions) was taken for each performance in this experiment, the first section for the first time the tests were performed, and the second section for the repetition.

The procedure is to add each of the successive pairs of the digits beginning at the top of the first column of a section, announcing the result of each addition and proceeding immediately to the next. The subject continues to announce the sum of every figure in the column plus the one next below it until he completes the task set, in this case one section on the sheet. Thus if the figures read 3, 6, 5, 1, 3, etc., the response is 9, 11, 6, 4, etc., the results being spoken without pronouncing the stimuli, in as rapid succession as the subject is able to make the addition mentally and articulate the response. He is interrupted only if he makes an error and in that case must correct it before proceeding to the next response. Preliminary practice until the situation is clearly understood is permitted, using a section of the sheet not included in the test section. The test section is covered until the "ready" signal as usual.

The score is the time taken to complete the task without error. A lower score indicates a better performance.

Test VI. Number Checking Test[16]*—Form A*

This is a test of discrimination and attention. In tests of discrimination, attention, distraction, etc., the task usually

[15]Psychological Monographs, Vol. XIII, No. 5, pg. 43. "Association Tests."

[16]Psychological Monograph, Vol. XIII, No. 5, pg. 24 ff. Association Tests, Woodworth and Wells.

consists of crossing out all cases of a given letter, figure, word or symbol or some combination of these, occurring on a printed sheet along with other material from which the given material is to be discriminated. The Number Checking Test requires the cancellation of a given digit or combination of digits.

Twenty properly spaced lines of fifty digits each, so arranged that each line contains 5 each of the digits, 1, 2, 3, 4, 5, 6, 7, 8, 9, 0, each successive fifth of the line (10 symbols) containing each of the ten symbols once, are printed in eight point type on a white background, to provide the material for the experiment.

The subject is instructed to cross out every one of a given symbol in each line on the sheet which is kept covered until he is instructed to start. He is told to proceed from left to right and to make sure that he crosses out five of the given number in each line. When he fully understands the directions the sheet is uncovered and the "Go" signal given at once. The time taken to complete the blank is recorded by stop watch. In this experiment the digit one was cancelled.

The score is the time required to make the entire 100 concellations. A lower score therefore indicates a better performance.

Test VII. Cancellation of a Letter[17]

This test differs from the Number Checking test only in that a selected letter is cancelled, instead of a digit, and there is not a systematic occurrence of the symbols in each line to aid the subject in checking the work as he proceeds. All the letters of the alphabet are arranged in random order, printed in pied type lower case letters, on a white background in lines as in a printed page, but with equal spaces between each of the letters. The letters are not broken up into groups as in words. Each letter of the alphabet occurs 50 times in the course of the material but the subject is not aware of this fact.

Stoelting provides two blanks[18] for this test, differing only in the order in which the letters occur. The blanks are of equal difficulty. One blank was used for the first test and the other for the re-test in this experiment.

[17]See Whipple "Manual of Mental, Physical Tests," pg. 305.
[18]C. H. Stoelting, Chicago, Blanks 27008 and 27009.

The subject is instructed to proceed from left to right as in the Number Checking test and cross out every one of the letters selected by the examiner that he meets as he proceeds systematically through line after line on the sheet. In the present instance the letter *a* was chosen.

The score is calculated on the basis of the formula:[19]

$$\text{Score} = \text{Time} + \frac{(\text{Time} \times \text{number of errors})}{50}.$$

Omitting the cancellation of a's or cancelling letters other than a's constitute errors. The time is the time taken by the subject to go through the blank systematically, once.

Test VIII. Cancellation of two letters

A slightly more difficult task is found in the cancellation of two letters instead of one. Interference enters into this performance.

Using the second blank,[20] that is the blank of equal difficulty with the form used for the first performance of Test VII and being the same as that used later for the second performance of Test VII, the subject crossed out the two letters b and m, proceeding as in Test VII. She was instructed to go through the sheet systematically crossing out every b and m on the sheet as she met it in her progress along the lines of letters. The sheet was kept covered as usual until ready to start.

Failure to cross out either of the letters designated or crossing out any other letters except those two constituted errors. The time was recorded for going through the blank once. In the re-test the blank used for the first performance of Test VII was used.

The score is based on the formula:

$$\text{Score} = \text{Time} + \frac{(\text{Time} \times \text{number of errors})}{100}.$$

There are fifty b's and fifty m's on the sheet, making 100 cancellations in all required. A better performance is indicated by a lower score.

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[19]Suggested by Pintner's Scoring of Substitution Test. See "A Scale of Performance Tests," pg. 65.

[20]See description, Test VII.

Test IX. Digit Span[21]

The digit span test is a test of rote memory. It is designed to determine the ability of the subject to reproduce with accuracy disconnected, non-logical material. Various methods of presentation are possible. The auditory method of presenting the stimuli was used in this experiment.

Series of digits, varying from 5 to 10 digits, three of each length were used. The subject was instructed to listen carefully while the examiner pronounced a series, and to respond immediately upon completion of the stimulus, by repeating the series in the exact order given by the examiner. The usual method of pronouncing the series, using an even tempo, at the rate of about one second per digit, clear articulation and absence of rhythm, was followed.

If the subject failed to repeat the first one of a series of a given length correctly, she was given a second trial with the next set of this series, containing the same number of digits but different ones. A third trial with still another set was given if necessary. If she succeeded in passing one of these three trials the examiner proceeded to the next longer series, and so on until the subject reached a digit span which she failed to repeat even once in three trials.

Thus if the subject succeeded in repeating a series such as 2, 6, 7, 5, 3, one of three trials on a series of five numbers, different numbers constituting the series each time, the examiner next tried such a series as 3, 5, 2, 6, 8, 1, giving the subject as many as three trials if necessary on a series of six, and so on until the limit was reached.

The score[22] consisted of the greatest number of digits in series repeated once in three trials. The larger the score, the better the performance indicated.

Test X. Paired Associates[23]

This is a memory test which requires the subject to listen to the reading of a list of pairs of words and to associate the pairs together so that later when the first of a pair is presented the subject can answer with the second. Two lists of twenty pairs each were used. One list consisted of pairs of

[21]Whipple, "Manual of Mental and Physical Tests," pg. 522, Vol. II.
[22]Following Terman in "The Measurement of Intelligence."
[23]Wallin's Lists: See C. H. Stoelting, Chicago, Catalogue of Mental Test Material.

words bearing no logical relation to each other, the second list of words having a distinctly logical relation to each other.

The subject was instructed as follows: "I shall read twenty pairs of words to you. When I am through I shall repeat the first word of each pair, and as I do so, you must give me the word that was given with it when I first read the pairs of words to you. As soon as I say a word, you reply with its associate, as rapidly as possible."[24]

When this was understood the examiner read the list of words, using an even tempo, taking about one minute for the entire list of twenty pairs of words. Having completed the reading she went through the list giving the first word of each pair and recorded the subject's response.

A score of 5% was given for each response where the word originally associated with the stimulus was recalled by the subject, 4% for one nearly correct, etc., following the standards for the use of the lists provided by Wallin.[25]

The score is the total number of points obtained. A higher score indicates a better performance. On working up the data it was found that there was as much gain in proportion between the first performance and second performance of both the logical and non-logical lists. Therefore the final score used for this test was the average of the scores for the logical and the non-logical lists.

Test XI. Woodworth and Wells Substitution Test[26]

This test measures the speed of learning new associations. It consists of filling out 100 blank forms in accordance with a key which is constantly referred to until it is gradually learned. As the subject learns the key he takes less time to fill out the blank, time being consumed less by less frequent reference to the key. The difference in the score the first time it is presented to a subject, and that of the second time, may be considered a measure of the difference in the speed of learning.

The blank is made up of five geometrical forms, the circle, square, triangle, star, and cross. Each is repeated on the blank 20 times and the arrangement follows the same rule as in the color naming Test II.

[24] Psychological Monograph, Vol. XIII, No. 5, pg. 53.
[25] Directions published by C. H. Stoelting, Chicago.
[26] Psychological Monograph, Vol. XIII, No. 5, pg. 53.

At the top of the blank appears a line containing each of the five forms once, with a number in each. This line being covered, the rest of the blank is exposed to the subject and it is explained to him that he is to write in each of these forms whatever number he finds in the corresponding form in the key. He is to proceed from left to right along the rows, taking each form as it occurs, never skipping about to fill in here and there on the sheet. When the subject has grasped the directions, the experimenter uncovers the key, immediately gives the signal "Go" and, using a stop watch, records the time taken to complete the blank, if the entire blank is used in the manner of this experiment. The score may then be computed by the formula,

$$\text{Score} = \text{Time} + \frac{(\text{Time} \times \text{number of errors})}{100}.$$[27]

The lowering of a score constitutes improvement.

Test XII. Woodworth and Wells Hard Directions Test[28]

Such factors as the speed of comprehension, the ability to follow directions, adjustability, clearness in thinking, are measured by the Woodworth and Wells Directions Test.

This calls upon the subject to follow certain directions, sometimes simple, sometimes complex, sometimes not altogether clear if not properly comprehended. They occur one after another printed on a blank which is presented to the subject with the simple instruction, "Do just what it says to do on this blank." He is to fill in the blank as rapidly as possible with the responses called for by the directions. There are twenty such directions and the score may be calculated on the basis of the time consumed in completing the blank and the number of errors, by the formula,

$$\text{Score} = \text{Time} + \frac{(\text{Time} \times \text{number of errors})}{20}.$$

A lower score indicates a better performance of the test.

Test XIII. Steadiness A

The apparatus[29] for testing the steadiness with which the subject can hold the outstretched arm, the form of steadiness

[27]Following Pintner and Patterson, "A Scale of Performance Tests," pg. 65.
[28]Psychological Monographs, Vol. XIII, No. 5, pg. 68.
[29]Whipple, "Manual of Mental and Physical Tests," pg. 155.

test used in this experiment, consists of a brass plate set at an angle of 45° and pierced with a series of 9 holes graduated from 7 to 32 sixty-fourths of an inch. This plate is connected with an electrically controlled counter. A metal stylus, connected in series with the plate, batteries and counter, is held by the subject and he is instructed to insert it in a given hole, keeping it there for a given length of time, during which he is to make an effort to avoid touching the sides of the hole. Every contact of the rod with the metal plate is recorded on the automatic counter.

To perform the test, the subject is seated comfortably before a table. The brass plate is placed flush with the edge of the table, in front of the subject's right shoulder for the test of steadiness of the right arm, and in front of the left shoulder for testing the left arm. He is instructed to hold the stylus in such a way that the finger tips are in contact with the expanded flange of the holder.

The subjects in this experiment first placed the tip of the needle within the largest hole and attempted to maintain the position without touching the brass plate during a period of 15 seconds. The hand and arm were free from all support or contact with the body or other object and the forearm formed an angle of approximately 100° with the upper arm. The needle was inserted about 6 mm. in the hole.

After a 15-second trial in the first hole, using the right hand, a 15-second trial in the same hole was made holding the stylus in the left hand. A rest of 30 seconds was then allowed. Next, the subject made a 15-second trial with the right hand putting the stylus in the next smaller hole, followed by a trial for this hole with the left hand. Proceeding thus with 30-second rest periods between trials in the successive holes, 4 of the holes were traversed in order of size.

The score consisted of the number of contacts made in the course of the entire experiment, right and left hand results being averaged. The lower the score, the better the performance indicated.

Test XIV. Steadiness B

A second form of the steadiness test was also tried out. With conditions controlled as in Test XIII and with the same apparatus, the test consisted of trying to hold the stylus for

one minute in the 13/64-inch hole without touching the sides. The score as before consisted in the number of contacts made. Right and left hand scores were averaged.

A lower score indicates a better performance.

Test XV. The Tapping Test[30]

This is a test of speed of movement. A brass plate is connected in circuit with a metal stylus. The plate is also connected with a counter where every contact of the stylus with the plate is recorded. To measure the speed of movement, the subject is instructed to hold the stylus in the hand as if it were a pencil, and to tap upon the metal plate, making an effort to execute as many taps as possible within the time given.

One minute was given, the time being measured by stop watch. The number of contacts executed in this time constituted the score, for each hand. These were recorded by the electric counter as the subject tapped. A larger score indicates a better performance. The scores for right and left hands were averaged, to simplify dealing with the data.

Test XVI. Endurance

A test of fatigability was desired but this was difficult to devise in the absence of elaborate apparatus. Also it is difficult to find a reliable measure of fatigue because so many factors have been found to influence the scores in many of the more obvious methods of securing them. It was thought that by recording the number of taps executed in the first half minute of the tapping test[31] and subtracting from that the number executed in the second half minute, a measure of fatigability might be obtained.

However, this is obviously a crude method, and is unreliable because of the possibility of great variability in the individual manner of performance. Some individuals tend to spurt in the beginning, some save themselves and spurt toward the end of the performance, others are fitful and uneven in their efforts and still others work regularly without much variability in their performance.

[30]Whipple, "Manual of Mental and Physical Tests," pg. 130.
[31]See Test XV.

In working up the data it was found that there appeared no difference in the fatigability of the two groups if judged by the differences in the averages for the two half minutes.

It was found, however, that there was a remarkable difference, one that clearly indicated some difference in the groups, showing a marked improvement in Group I after treatment, when the performance in the second half minute was compared without balancing it against that of the first half minute.

This cannot be considered a measure of fatigability, except indirectly. It does, however, indicate endurance, or the ability to continue to react after a given amount of preliminary activity, in this case, the first half minute of tapping.

The score is the number of taps executed in the 1-minute tapping test minus the number executed in the first half minute averaged for right and left hands. The examiner recorded the position of the counter at the end of the first half minute. A higher score indicates a better performance.

Test XVII. Co-ordination. The Three Hole Test of Combined Accuracy and Speed[32]

This test includes along with steadiness and speed, which are essentially motor and physiological, the more strictly mental factor of co-ordination.

An oak plate tilted at an angle of 45° to the base board contains three brass-lined holes[33] arranged in the form of an equilateral triangle with the centers about 10 cm. apart. Contact of a metal stylus with the bottom of a hole makes an electrical connection which is recorded by an automatic counter. The subject holds the stylus in his hand and inserts the stylus in the three holes successively as rapidly as possible until 100 contacts have been made, the time to execute the performance being recorded by stop watch.

The right hand was used in this experiment. The score is the number of seconds required to execute 100 contacts. A lower score indicates a better performance.

Success in this test requires not only the bringing of a single set of muscles into harmonious action, as in the tapping test, but also the co-ordination of several sets of muscles under

[32]Designed by R. S. Woodworth, 1904.

[33]An improved form of this apparatus designed by Woodworth in 1923 is now in use in the Psychological Laboratory of Columbia University. The older apparatus is used in this experiment.

visual guidance, and this must be brought about as rapidly as possible. The accuracy and speed involved are brought under the control of a purely mental effort.

V. Results

1. The most obvious way of handling the data for bringing out any effect of the sanitarium treatment for intestinal toxemia on mental performances would be to find the average score of Group I before treatment, and after treatment, and see whether the score is improved. But this simple procedure is subject to the fallacy that improvement may be partly due merely to the practice obtained in the tests by virtue of simply taking the tests twice. It is to obviate that fallacy that the control Group II was tested.

Group II being fairly comparable in age and intelligence with Group I, and being tested with the same tests in the same way and at the same interval between first and second tests, shows what gain Group I could be expected to make without the treatment for toxemia.

The gross gains actually made by Group I are presumably composed of two parts: the gain due to treatment, and the gain due to practice. If, therefore, the average gain of Group II is deducted from the gross gain of Group I, the remainder may fairly be considered the net gain of Group I, resulting from the treatment for toxemia.

Accordingly, the first and simplest way in which the data can properly be handled is that shown in Table IX.

The average score of Group I in each test is shown before and after the month of treatment, and the gross gain made by Group I is the difference between the averages before and after treatment. (This gross "gain" might be negative, i.e., there might actually be a loss; but this result was not obtained with Group I in any test in the average of the whole group.) Similarly, the average scores of Group II before and after the one month interval (without treatment) are shown, and the gain of Group II (gain due to practice, to be eliminated in order to reveal any gain due to treatment). This average gain of Group II is now subtracted from the gross gain of Group I, and the remainder is the net gain of Group I, the gain presumably due to treatment for toxemia. This net gain would be negative in case the control group actually gained

TABLE IX

	Test	Group I Av. A	Group I Av. B	Group I Gross Gain	Group II Av. A	Group II Av. B	Group II Gain	Net Gain Amount	Group I % Gain
I	Free Association	96.03	121.00	24.97	99.30	110.90	11.60	13.37	14.00
II	Color Naming	61.57	54.47	7.10	60.77	57.93	2.74	4.36	7.00
III	Opposites	32.21	22.72	9.49	24.37	23.83	.54	8.95	28.00
IV	Constant Increment	135.67	119.60	16.07	148.02	129.02	19.00	—2.93	—2.16
V	Kraepelin Addition	140.41	114.66	25.75	152.15	132.62	19.53	6.22	4.42
VI	Cancellation I	108.41	92.17	16.24	104.50	95.00	9.50	6.74	6.21
VII	Cancellation a	156.91	138.12	18.79	181.37	166.43	14.94	3.85	2.46
VIII	Cancellation b m	290.25	244.20	46.15	297.74	260.90	36.84	9.31	3.20
IX	Auditory Mem. Span	6.67	7.23	.56	7.50	7.76	.26	.30	4.50
X	Paired Associates	59.85	70.10	10.25	66.87	72.90	6.03	4.22	7.00
XI	Substitution	133.34	122.54	10.80	134.88	123.53	11.35	—.55	—.43
XII	Directions	226.11	111.82	114.29	143.48	106.03	37.45	76.84	33.90
XIII	Steadiness A	4.00	2.00	2.00	7.00	9.00	—2.00	4.00	100.00
XIV	Steadiness B	6.00	3.00	3.00	6.00	6.00	.00	3.00	50.00
XV	Speed of Tapping	332.00	354.00	22.00	356.00	353.00	—3.00	25.00	7.53
XVI	Endurance	161.00	173.00	12.00	173.00	171.00	—2.00	14.00	8.70
XVII	Co-ordination	76.01	70.60	5.41	59.60	58.16	1.44	3.97	5.09
	Av.								16.43
	S. D. Dis.								24.80
	P. E. Av.								4.04
	Av./P. E.								4.10

more in a given test than the treated group; but such a negative gain only occurs in two out of the 17 tests, and then only to a slight degree. In 15 out of the 17 tests, the treated group gained more than the control group, so that the net gain due to treatment is positive. The amount of this net gain is now expressed as a per cent of the original score of Group I and thus the results in the several tests can be compared and combined.

Though net gain in the several tests is very unequal, it does not appear that any special information is to be obtained by considering the tests separately. They are best considered simply as so many sample mental performances, and the total results of all the tests together is the best index of the mental effect of the treatment.

These results indicate that the average net gain in the performance of Group I was 16.43%, approximately 16%. This is to say the experiment shows a net increase of approximately 16% in the mental and motor efficiency of the particular group under consideration, after treatment had resulted in changing the flora so that the condition of intestinal toxemia was practically removed.

The probable error of the average net gain expressed in terms of per cent of the original performance is 4.04 and the average expressed in P. E. units is 4.10. This means that the average is 4.1 P. E. above zero and the probability that it would be reduced to zero by further sampling with a wider range of similar tests is very slight. The chances[34] are more than 9999.7 in 10,000 that there is a real gain in the performance of Group I beyond what can be accounted for by practice.

Table X shows the S. D.$_{dis}$ and P. E.$_{av}$[35] for the two groups.

These figures show how the individuals are distributed about the average of the group. Where the standard deviation is larger it shows that the individuals tend to vary from the average by greater amounts than where this measure is smaller, for instance, the S. D. of the distribution of the scores on the free association test is 28.18. This shows a greater deviation on the average for the individual scores than in the

[34]See Rugg, "Statistical Methods Applied to Education," pg. 391.

[35]S. D.$_{dis} = \sqrt{\frac{\Sigma d^2}{n}}$ P. E.$_{av} = \frac{.6745 \times \text{S. D.}_{dis}}{\sqrt{n}}$

TABLE X

	Performance *A* and *B*	Group *I* and *II*											
		Group I						Group II					
		Perf. A			Perf. B			Perf. A			Perf. B		
	Test	Av.	S. D. Dis.	P.E. Av.	Av.	S. D. Dis.	P. E. Av.	Av.	S. D. Dis.	P. E. Av.	Av.	S. D. Dis.	P. E. Av.
I	Free Association	96.03	28.18	3.47	121.00	23.38	2.78	99.30	24.39	3.00	110.90	26.75	3.28
II	Color Naming	61.57	11.40	1.40	54.47	8.33	1.02	60.77	15.36	1.89	57.93	10.96	1.35
III	Opposites	32.21	22.40	2.75	22.72	5.74	.71	24.37	5.77	.71	23.83	5.31	.65
IV	Constant Increment	135.67	66.44	8.18	119.60	54.91	6.76	148.02	87.47	10.76	129.02	66.63	8.19
V	Kraepelin Addition	140.41	36.25	4.46	114.66	25.90	3.18	152.15	44.58	5.48	132.62	37.72	4.64
VI	Cancellation I	108.41	24.79	3.05	92.17	16.10	1.98	104.50	27.00	3.32	95.00	15.08	1.85
VII	Cancellation a	156.91	43.59	5.36	138.12	22.21	2.73	181.37	37.62	4.63	166.43	41.84	5.13
VIII	Cancellation b m	290.25	76.68	9.43	244.20	51.58	6.35	297.74	63.64	7.83	260.90	53.39	6.57
IX	Auditory Mem. Span	6.67	1.41	.18	7.23	1.19	.15	7.50	1.05	.13	7.76	1.17	.14
X	Paired Associates	59.85	9.42	1.16	70.10	11.74	1.44	66.87	13.49	1.66	72.90	16.26	1.96
XI	Substitution	133.34	22.19	2.60	122.54	14.24	1.74	134.88	21.25	2.61	123.53	19.42	3.39
XII	Directions	226.11	284.72	35.04	111.82	41.44	5.10	143.48	45.09	5.53	106.03	34.49	4.24
XIII	Steadiness A	4.00	3.96	.49	2.00	2.30	.28	7.00	5.49	.67	9.00	5.66	.69
XIV	Steadiness B	6.00	6.42	.79	3.00	3.97	.49	6.00	6.14	.76	6.00	1.29	.16
XV	Speed of Tapping	332.00	27.53	3.39	354.00	28.00	3.46	356.00	37.98	4.67	353.00	37.62	4.63
XVI	Endurance	161.00	16.03	1.97	173.00	16.73	2.06	173.00	19.70	2.43	171.00	19.56	2.41
XVII	Co-ordination	76.01	11.78	1.45	70.60	7.67	.94	59.60	7.93	.98	58.16	8.45	1.04

color naming test where the S. D. is only 11.40. The smaller, in proportion, the P. E. of the average, the more reliable and less subject the average is to wide variations by further sampling.

2. This simple statistical treatment does not take account of individual variations which should also receive consideration in order to check up the reliability of the result.

Here we may take into consideration whether an individual improved in all of the tests and, if not, in how many of the series she did improve. Also how many individuals in Group I reached or exceeded the average of Group II and so can fairly be credited with a net gain.

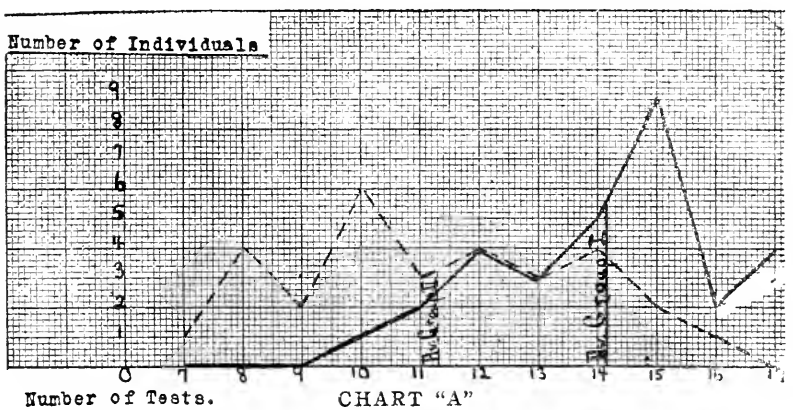

CHART "A"

Showing the Distribution of Gains in Individual Tests Groups I and II

Chart A shows the distribution of individuals according to the number of tests in which each showed improvement. The continuous line shows the distribution for Group I, the dotted line for Group II.

In Group I no individual failed to improve in less than ten tests. Referring to Chart A we see that only one individual improved in as few as ten tests and the average number of tests in which Group I shows improvement is 14.1. The mode, 9 individuals, is at 15 and 4 individuals show improvement in every one of the 17 tests.

Group II shows individual gains in not less than seven tests and not more than 16, one individual having gained in seven and one in 16 of the seventeen tests in the series. The average number of tests in which the individuals of Group II show

gains is 11.3 tests. The mode where 6 individuals show gain is at 10 tests.

The problem of how many individuals in Group I showed a mental improvement due to treatment can also be examined in Chart A. We learn from Chart A, that an individual retested in these tests without treatment, can be expected to show a gain in 11.5 out of 17 tests on the average. When any individual of Group I, the treated group, shows a gain in more than this number of tests the chances are in favor of his having profited, mentally, from sanitarium treatment. By this rough criterion all but three of the treated group showed some mental gain from treatment.

There is another way of reaching an estimate of the number of individuals in Group I who showed an improvement due to treatment. Of course, we have no way of knowing what would have been the gains of the individuals in Group I if they had simply repeated the tests, as Group II did, without sanitarium treatment. The best estimate that we can make of what this individual gain due to practice would have been is to take the average gain for Group II as the normal gain to be expected from practice. If an individual of Group I shows a gain in a test exceeding the average gain of Group II, then we can say that this individual made some gain due to treatment. If she showed a net gain in only a few of the tests, that might be a chance result. She should show a net gain in at least half of the tests in order to be counted as gaining from treatment.

Table XI shows the number of individuals in Group I who may be said to show a net gain judged by the criterion of having exceeded the average gain of Group II in more than half of the tests.

TABLE XI

NUMBER OF TESTS IN WHICH INDIVIDUALS OF GROUP I EXCEED THE AVERAGE GAIN OF GROUP II

Number of Tests	*Number of Individuals*
7	1
8	5
9	2
10	2
11	7
12	1
13	4
14	3
15	3
16	1
17	1
Av. 11.5	

The table is to be read as follows: No one in Group I showed a net gain in fewer than 7 of the 17 tests; one individual showed a net gain in only 7 tests, and 5 individuals in only 8 tests; all the others showed a net gain in at least 9 tests, i.e., in over half of the tests. Thus the indications are, roughly, that 24 out of the 30 treated individuals showed a mental improvement due to the treatment.

Following the method of calculating the number of individuals of Group I, making net gains, discussed in connection with Chart A, we found that 27 out of the 30 treated individuals made net gains. Averaging the results obtained by the two methods, both somewhat too rough to insure against slight differences in results, we may estimate with a fair degree of reliability that about 25 of the 30 individuals of Group I benefited mentally by the treatment.

3. The preceding modes of handling out data lack certain statistical refinements which can be employed in order to answer what is our most serious problem,—whether, that is to say, the apparent net gain, due to treatment, has sufficient statistical reliability to be accepted as a scientific conclusion. The preceding methods, as illustrated especially in Table IX (the table with per cents of net gains) are somewhat rough and ready. They lack refinement in two respects: (1) in the manner of combining the gains in the several tests, or making them comparable—the method of reducing net gain to a per cent of original average score, failing to take due account of the variability of performance in each test; and (2) in failing to consider the gain of each individual as a basis for computing the variability of gain and so the reliability of the average net gain.

To illustrate (2), we may take an example as follows: Examining typical sets of scores for the opposites test, we find, for instance, that individual No. 12 in Group I, Performance A, scored 27 seconds, and individual No. 13 scored 21 seconds. There is a difference of 6 seconds in these gross scores. In Performance B of these two individuals we find that No. 12 scored 24 seconds, a gain of 3 seconds, and No. 13 scored 18.2, a gain of 2.8 seconds. The difference between the gains is only .2 second whereas the difference between the raw scores in Performance A was 6, and in Performance B, 5.8 seconds.

The absolute variability of the gains is therefore less and it is also true that, though the individual scores may vary

widely with each other, the gains for the individuals are more nearly alike, the subjects tending to gain in amounts more nearly alike, though they may vary widely in their original performance.

Since the statistical treatment of the data (calculation of P. E., etc., see following) takes into consideration the variability of the measures, a more accurate estimate of the situation can be obtained from treating the individual gains where variability as a source of inaccuracy is reduced to a minimum, than from treating the raw scores for the individual performances, where the variability is greater.

To refine upon previous methods, therefore, two procedures were adopted: (1) the gains of each individual for each test were found for both groups and the average, S. $D._{dis}$ and P. $E._{av}$ of the gains for each test were computed for each group; (2) the Probable Error of the difference,[36] in the average gains of Group I and Group II, which is equivalent to the P. E. of the net gain of Group I, was calculated for each test. The difference in the average gains of the two groups, or the net gain of Group I, was expressed in P. E. units.[37] By averaging the resulting net gains of Group I in the several tests expressed in P. E. units as a common measure, and finding the P. E. of this average, we reach a tangible means of expressing and determining the reliability of our results taken as a whole.

These procedures give us Table XII, as follows:

The average of the net gains expressed in P. E. units is 2.62 with a P. E. of .30. This indicates that the average is a very reliable one. Since it is 8.8 times its P. E. it is practically certain that the average is more than a chance occurrence and further sampling would not reduce it to zero. The distribution of the net gains expressed in P. E. units is shown in the following chart B.

This distribution is consistent with and illustrative of the reliability of the general result. As the diagram (Chart B) shows, the net gains expressed in P. E. units are closely grouped about their average. All but two are positive and the two negative measures –.55 and –.88 are so small that they are of little significance. The distribution follows fairly well

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[36] P. E. Diff. $= \sqrt{(P.\ E._{av})^2 + (P.\ E._{av_2})^2}$

[37] P. E. Units of Diff. (Av. expressed in P. E. Units) $= \frac{Av_2 - Av_1}{P.\ E.\ diff.} = \frac{Am't\ Net\ gain}{P.\ E.}$

TABLE XII

Results Obtained from Treatment of Individual Gains

Groups I and II

	Test	Group I			Group II			Net Gain		
		Gross Gain	S.D. of Indiv. Gain	P. E. Av.	Gross Gain	S.D. of Indiv. Gain	P. E. Av.	Am't.	P. E.	Am't. P. E.
I	Free Association	24.97	16.70	2.06	11.60	18.35	2.26	13.37	3.05	4.20
II	Color Naming	7.10	5.52	.67	2.74	11.87	1.46	4.36	1.60	2.70
III	Opposites	9.49	19.79	2.43	.54	4.52	.56	8.95	2.38	3.93
IV	Constant Increment	16.07	25.03	3.08	19.00	34.55	4.25	—2.93	5.25	—.55
V	Kraepelin Addition	25.75	24.34	2.99	19.53	17.57	2.16	6.22	3.68	1.71
VI	Cancellation I	16.24	18.90	2.32	9.50	20.50	2.50	6.74	3.41	1.96
VII	Cancellation a	18.79	23.70	2.90	14.94	24.40	2.99	3.85	4.07	.96
VIII	Cancellation b m	46.15	54.90	6.75	36.84	47.67	5.87	9.31	8.94	1.04
IX	Auditory Mem. Span	.56	.76	.09	.26	.67	.08	.30	.12	2.50
X	Paired Associates	10.25	10.60	1.31	6.03	11.50	1.42	4.22	1.93	2.17
XI	Substitution	10.80	16.90	—8.80	11.35	13.07	1.62	—.55	2.63	—.88
XII	Directions	114.29	221.70	27.24	37.45	32.74	4.03	76.84	27.50	2.91
XIII	Steadiness A	2.00	3.13	.38	—2.00	4.81	.59	4.00	.72	5.60
XIV	Steadiness B	3.00	5.84	.71	.00	4.95	.61	3.00	.93	3.20
XV	Speed of Tapping	22.00	22.50	2.76	—3.00	28.90	3.55	25.00	4.50	5.40
XVI	Endurance	12.00	15.75	1.94	—2.00	18.03	2.22	14.00	2.95	4.70
XVII	Co-ordination	5.41	8.51	1.05	1.44	10.62	1.30	3.97	1.33	3.00
	Av.									2.62
	S. D.									1.84
	P. E. Av.									.30
	Av./P. E.									8.80

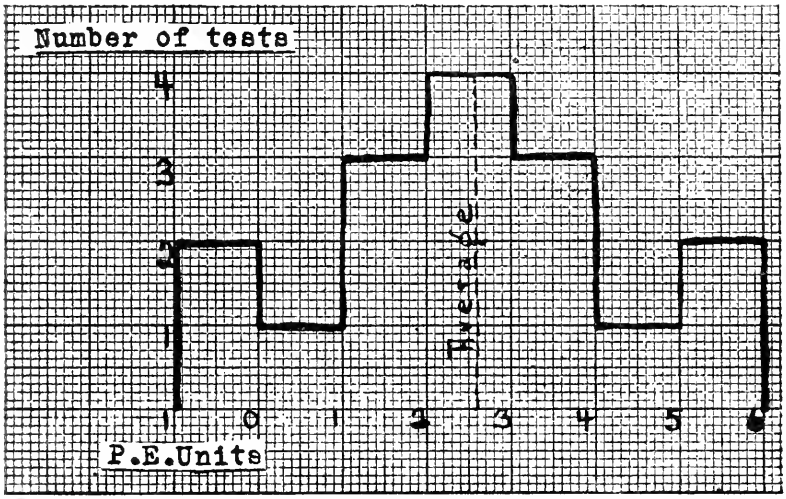

CHART "B"

Distribution of Net Gains Expressed in P. E. Units

the normal curve, except for the two spurs, one at the lower end and one at the upper end of the diagram, each comprising two cases.

VI. Conclusions

The average net gain expressed in P. E. units is 2.62 with a P. E. of .30.[38] This average is 8.8 times its P. E. which as stated in the previous section indicates that it is practically certain that with further sampling with a similar series of tests, or with a similar group of subjects treated, the average will not fluctuate beyond the usual limits of –2 P. E. and +2 P. E. that is below 2.02 or above 3.22, and no amount of further sampling would reduce it to zero.

This means that it is practically certain that there is some real difference in Group I as a result of the treatment for intestinal toxemia as defined in Section I. Stated mathematically in terms of probability based on the average difference in performance expressed in P. E. units, the chances[39] are more than 9999.7 in 10,000 that treatment for intestinal toxemia of the nature under discussion in the manner described in a previous

[38] See Table XII.
[39] See Rugg, "Statistical Methods Applied to Education."

section, would result in a gain in mental and motor efficiency. It means that the net gain shown by Group I could not be due to chance alone.

The net gain for Group I in this experiment was roughly estimated at approximately 16% (see Table IX). This is based on the net gain in the total series of mental and motor tests.

The first twelve of these tests may be considered more strictly mental tests, being more purely intellectual than the remaining five which are more distinctly motor in nature. If the average net gain for the twelve more purely mental tests is computed independently of the motor series, it is found that the average for the mental series is 9.21% and for the motor 34.38%, a ratio of approximately 1 to 4.

It would appear, therefore, that motor reactions are improved to a greater extent by the treatment for intestinal toxemia than the more intellectual processes are.

In this we are reminded of Dodge's results with the administration of alcohol. Dodge, in a recent study, has shown that the more complex functions, such as memory and thinking, show less effect under the administration of alcohol than do simple reflexes. In general, Hollingworth and Dodge have found decrease in mental and motor efficiency under the administration of alcohol.

On the other hand, Hollingworth has shown an increase in mental and motor efficiency under the administration of caffeine. Jones, using the ergograph, has found a general increase followed by a decline in the amounts of work under the administration of large doses of strychnine, while Poffenberger reports no effect on steadiness and speed of movement from small doses of the same drug.

Studies on hookworm and diseased tonsils show practically no effect of these conditions on general intelligence. Poor ventilation does not appear to affect the efficiency of the mental worker, according to the work of Thorndike and Stecher at the laboratory of the New York State Commission on Ventilation.

The results therefore of studies on the effect of endogenous as well as exogenous poisons on mental and motor efficiency vary, but this may be partly due to the fact that different examiners have used different methods or materials and have measured somewhat different aspects of the problems under consideration. In general, it would appear that in the present

state of our knowledge there is as much evidence in favor of the opinion that mental performances are affected by these conditions as against it. Results of the study on intestinal toxemia seem most definitely to indicate that an exogenous poison of the sort produced by the pernicious flora present in the intestine in this condition, may decidedly affect the mental and motor efficiency of the sufferer.

In treating the toxemia, other than intestinal treatment was resorted to, though all are supposed to have an effect upon the intestinal condition and were considered responsible for the change in the flora. At the same time, it must be taken into consideration that this treatment itself may have had some influence upon the improvement of the mental condition above that which would have resulted from changing the flora by purely intestinal treatment.

Some evidence, though not very definite, has been advanced for the mental effect of periods of training in athletics and for various dietary systems. Exercise and diet entered to some extent into the treatment of Group I.[40] It is impossible to correlate the various elements in the total situation with the result by any of the ordinary correlation methods owing to the limitations of the data, and as previously stated it is impossible to determine just how much each element of the situation has entered into the result.

For instance, we cannot correlate gain in intestinal condition with gain in mental condition because we find that the gain in intestinal condition can be expressed only in terms of four degrees of difference in the improvement made by the individuals in the treated group, namely, 20%, 40%, 60% and 80%,[41] and there is no correlation method which would apply to the case.[42] The fact remains, however, that the intestinal condition as measured was changed and it is quite possible that this played a part in the result, that is, the change in the mental condition following upon the total regime.

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[40]See pages 13 and 14.

[41]Compare Tables IV and VI.

[42]Though no correlation method can be applied, we may split the gains in mental efficiency into four groups to correspond with the four groups in the gains in intestinal condition with the result as follows:

GAIN IN INTESTINAL CONDITION

	Rank	*1*	*2*	*3*	*4*
Gain in		*Number of Individuals*			
	1	0	1	5	1
Mental	2	1	1	5	1
	3	2	2	3	0
Tests	4	11	5	2	0

This is not a very satisfactory result. It shows no definite relationship between the amount of gain in mental efficiency and the amount of gain in intestinal condition. On the other hand, it shows a definite lack of correspondence between the two extremes, no individual in grade 1, the greatest gain in either condition falling in the same group with regard to the other condition. Likewise, none of the poorest, grade 4, in one condition falling in the same grade with regard to the other. But 3 individuals in grade 3 are alike in improvements in both conditions and likewise 1 individual in grade 2. There is more or less divergence with regard to the rest of the group.

This does not necessarily mean that there is no relation between gain in intestinal condition and gain in the mental tests, but rather that with the data at our disposal we are unable to work out the relation between the amount of gain in the one and the amount of gain in the other.

The subjective reports of those who took part in the experiment corroborated the positive result obtained. Practically all of the individuals comprising Group I, the treated group, reported an improvement in their general feeling and ability to work as a result of their period of treatment.

As previously stated, a psychologist, in such an investigation as this, is, of course, no judge of the bacteriological and metabolic factors involved. He is no judge of the effectiveness of the various elements of the treatment employed, nor of the causative relations between the intestinal and mental changes which were experimentally found to occur. What the psychologist can assert is that treatment designed to correct intestinal toxemia, and consisting of a diet (etc.), adequate elimination, exercise, hydrotherapy, and a cheerful environment, did actually result in an improvement in mental efficiency. Along with this improvement there also occurred an improvement in the intestinal flora, as determined by the bacteriologist. With a complex treatment such as that described, which changes several conditions of the subject's life concomitantly, it is not possible for us to assign the resulting mental improvement to any one of the changed conditions, as against others. The reader is again reminded that we simply attest a mental change for the better resulting from the treatment as a whole.